8.4: Metabolic

Metabolic parameters are detected, and functions derived from those parameters are computed in *LabScribe's* **Metabolic Advanced Analysis Module**.

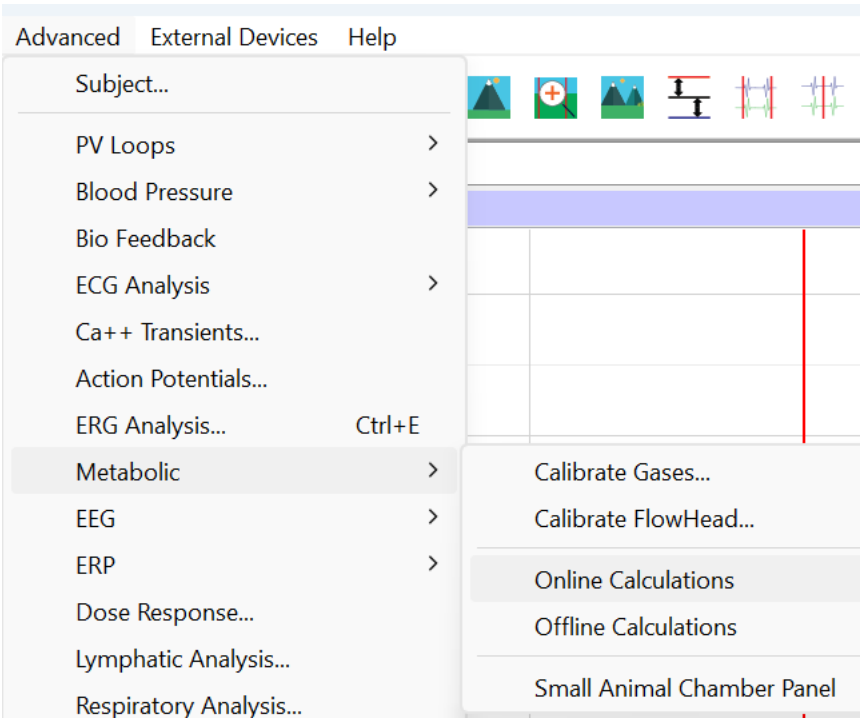
The **Metabolic Advanced Analysis Module** can both analyze online data as they are being collected, and perform offline analysis of previously recorded data files.

This document includes a **Step by Step** tutorial for using most of the features of the **Metabolic Advanced Analysis Module**, as well as a more detailed **Reference** section that covers the material in the tutorial, and adds additional context and detail. To use the **Step by Step** guide, you will need a recording with metabolic data. In order to use the online analysis part of the module, you will need to be recording these parameters as you proceed through the tutorial. This file can then be saved and used in the offline analysis tutorial.

For users not familiar with how to use iWorx hardware and software to generate a file with metabolic data, a checklist for setting up the metabolic cart, and configuring *LabScribe* to record metabolic data, follows the **Step by Step** and **Reference** sections of this document. Detailed hardware and software instructions are also included in the individual **Human Exercise** lab exercises that utilize iWorx gas analyzers. There are also instructional videos available at iworx.com illustrating the process.

Metabolic Analysis: Step by Step

The **Metabolic Analysis Module** automatically opens as part of any of the Metabolic Labs using one of the gas analyzer systems or metabolic carts. Or **Metabolic** can be chosen from the **Advanced** menu, a submenu opens, displaying three options: **Calibrate flow head**, **Online Calculations**, and **Offline Calculations**.



Metabolic submenu

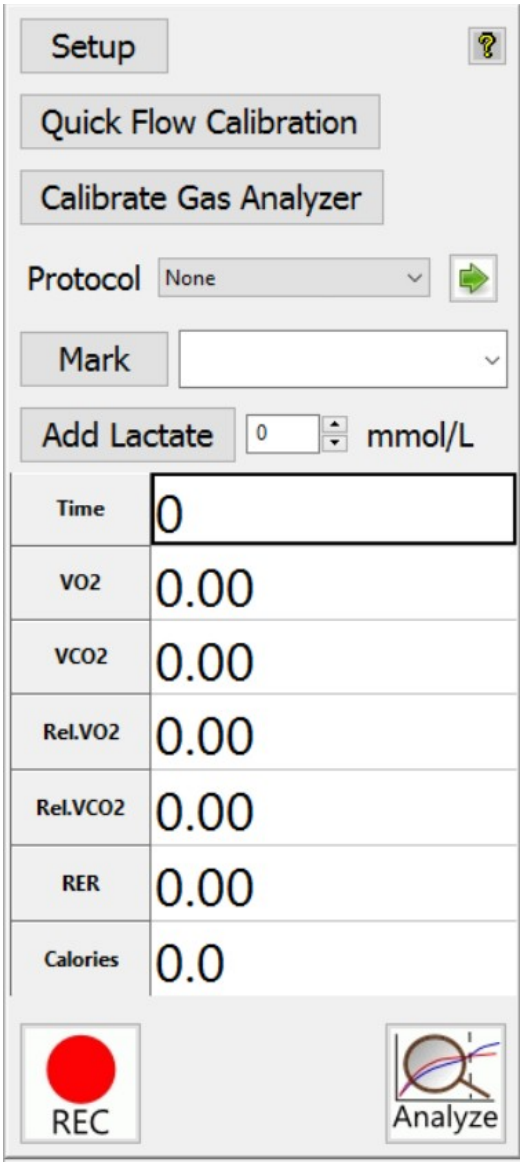
Complete instructions for using the **optional** flow head calibration routine **<Calibrate flow head>** dialog can be found in the **Spirometer Calibration** exercise found in the **Human Exercise-GA200, Human Exercise-GA300,** and **Human Exercise-iWireGA** folders of the complete *LabScribe* installer. This flow head calibration only needs to be completed if using the IX-214 or IX-228 data acquisition systems.

The **Online Calculations** and **Offline Calculations** options provide analysis of metabolic experiments that use a mixing chamber such as the experiments in the **Human Exercise-GA200, Human Exercise-GA300,** and **Human Exercise-iWireGA** folders of the complete *LabScribe* installer.

Online Calculations

To use the **Online Calculations:**

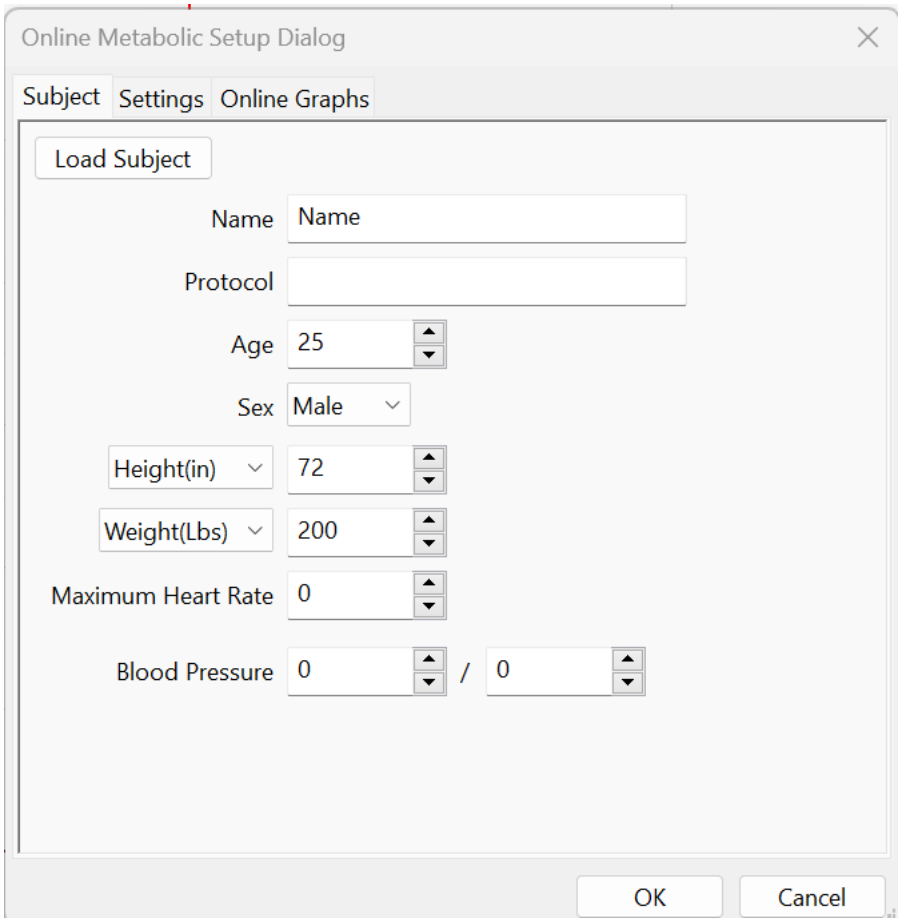
To perform real-time analysis of mixing chamber metabolic data, *LabScribe* needs to be configured as in the experiments in the **Human Exercise-GA200, Human Exercise-GA300** and **Human Exercise-iWireGA** folders. The procedure for setting up the iWorx hardware and software is also summarized after the **Reference** section of this manual. Using the **Online Calculations**, it is possible to generate metabolic calculations in real time.



1) Configure the hardware and *LabScribe* software to record mixing chamber metabolic data.
2) Record a sample, autoscaling all channels. Stop recording as you configure the online analysis.
3) Choose **Online Calculations** from the **Metabolic** submenu to display the **Metabolic Toolbar** if it does not open automatically.
   - NOTE – if using the latest version of the *LabScribe software*, the module will open automatically.

Setup

Choose **Setup** to open the **Online Calculation Setup** dialog.

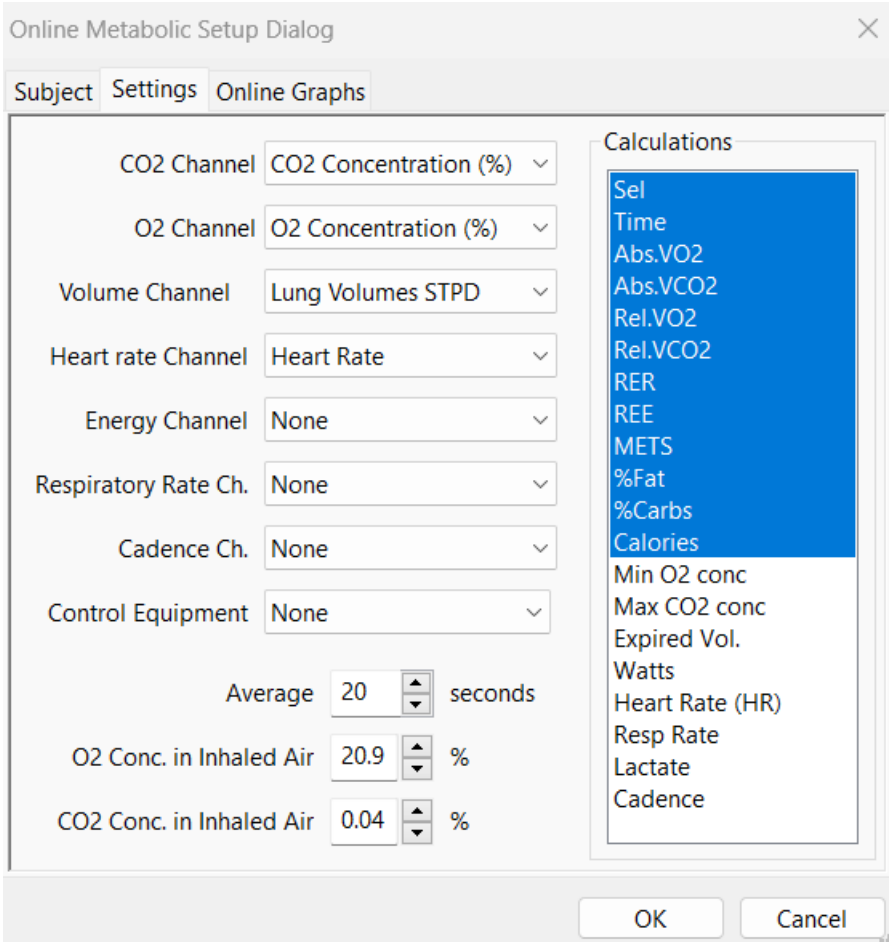


Subject Information:

Enter the Subject information or load a saved Subject file.

Height and weight can be change from kg cm and kg to in and lbs.

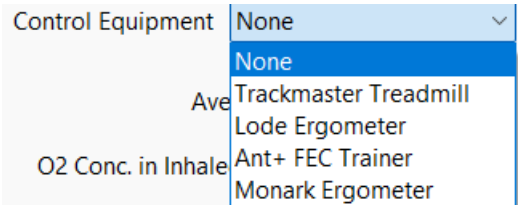
NOTE – this should be set up automatically.



Settings

1. From the **CO2 Channel** menu, choose the % CO_2 channel from your recording.
2. From the **O2 Channel** menu, choose the % O_2 channel from your recording.
3. From the **Volume Channel** menu, choose the volume channel from your recording.
4. Choose the Heart Rate, Energy, Respiratory Rate or Cadence Channel if present.
5. Choose the equipment that you want to control, if any.
   This requires the LS-ME LabScribe Metabolic Equipment Control Module.
   - **Treadmills**: Treadmill that support the Trackmaster Protocol, such as treadmills from Trackmaster, Woodway
   - **Ergometers** :
     - Ergometers supporting the ANT+ FEC Trainer protocol
     - Monark ergometers with a serial connection
     - Lode Ergometer

   The protocols are used to send the comands to the equipment

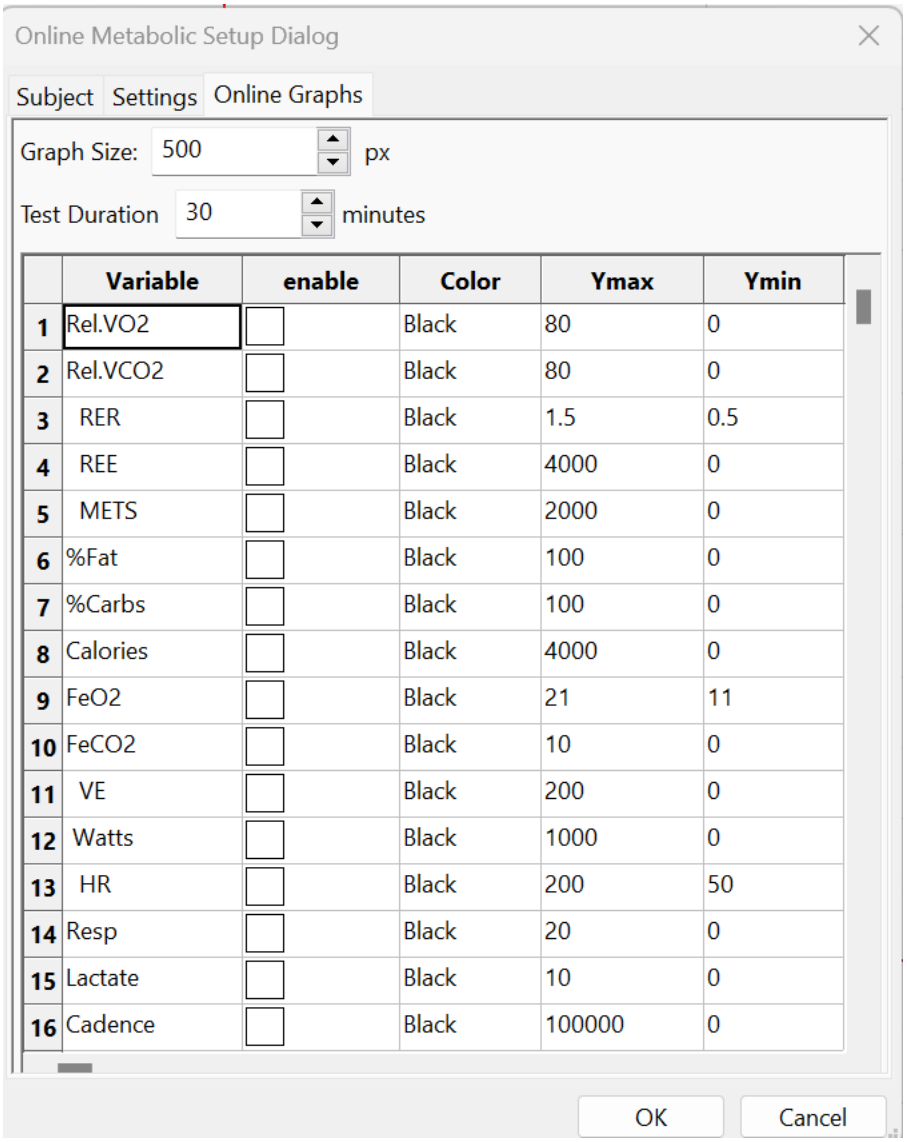


6. In order to compensate for variation from breath to breath, it is possible for *LabScribe* to average the data over a segment of time. In the text box to the right of **Average**, indicate the segment duration you would like to average for analysis. The ACSM recommends an averaging time of twenty (20) seconds.
7. In the text box to the right of **O2 Conc. in Inhaled Air**, indicate the oxygen concentration of inhaled air,

usually 20.9%.

8. In the text box to the right of **CO2 Conc. in Inhaled Air**, indicate the carbon dioxide concentration of inhaled air, usually 0.04%.
9. From the **Calculations** list, control-click on those variables you would like to record in the data boxes of the **Metabolic Toolbar**. To remove a variable after you have selected it, control-click on that variable. Definitions of all variables can be found in the **Metabolic Analysis: Reference** section.

Online Graphs



	Variable	enable	Color	Ymax	Ymin
1	Rel.VO2	☐	Black	80	0
2	Rel.VCO2	☐	Black	80	0
3	RER	☐	Black	1.5	0.5
4	REE	☐	Black	4000	0
5	METS	☐	Black	2000	0
6	%Fat	☐	Black	100	0
7	%Carbs	☐	Black	100	0
8	Calories	☐	Black	4000	0
9	FeO2	☐	Black	21	11
10	FeCO2	☐	Black	10	0
11	VE	☐	Black	200	0
12	Watts	☐	Black	1000	0
13	HR	☐	Black	200	50
14	Resp	☐	Black	20	0
15	Lactate	☐	Black	10	0
16	Cadence	☐	Black	100000	0

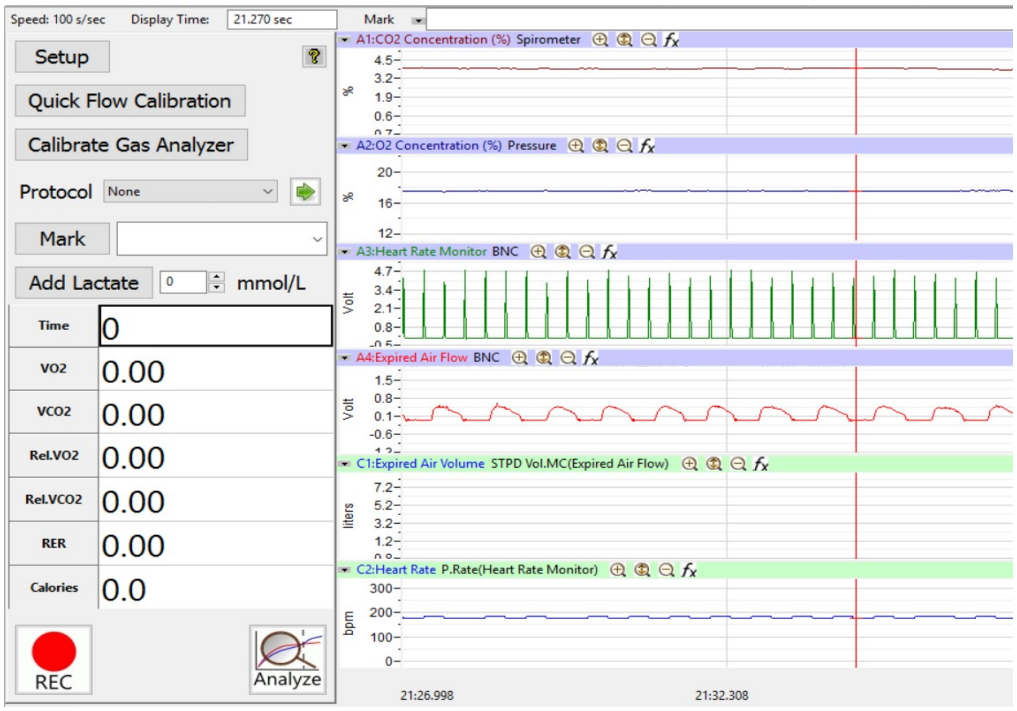
Various graphs can be displayed during recording.

Choose the size of the graph window.

Set the duration of the test.

Choose the variables that you want to plot, along with the color and scaling.

Click **OK** to close the dialog.



nline Metabolic main window display.

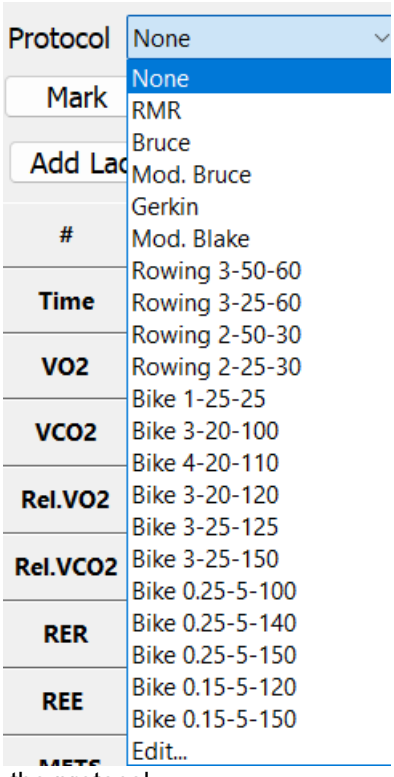
Flow Calibration

Click on the **Quick Flow Calibration** button to start the flow calibration. Follow the onscreen prompts.

Calibrate Gas Analyzer

Click on the **Calibrate Gas Analyzer** button to start the gas calibration. Follow the onscreen prompts.

Protocols:



Labscribe comes with preset protocols for performing some common Metabolic tests, such as RMR, Bruce, Modified Bruce, Gerkin, Modified Blake, Rowing, Biking etc... These protocols can be customized by choosing the edit option.

To Run a protocol, choose the protocol from the drop-down list and then click the Green arrow. The Program will start recording data and run the selected protocol.

If using the LS-ME LabScribe Metabolic Equipment Control Module to control external exercise equipment, the protocol can be used to setup the commands to be sent to the external exercise equipment. For example with a treadmill, the gradient and the speed of the treadmill can be set from the protocol.

Marks:

During recording marks can be placed in the record, When protocol is run, the stages of the protocol are automatically marked. Various marks can be preset.

If measuring Lactate values, they can be entered in the record by clicking on the **Add Lactate** button.

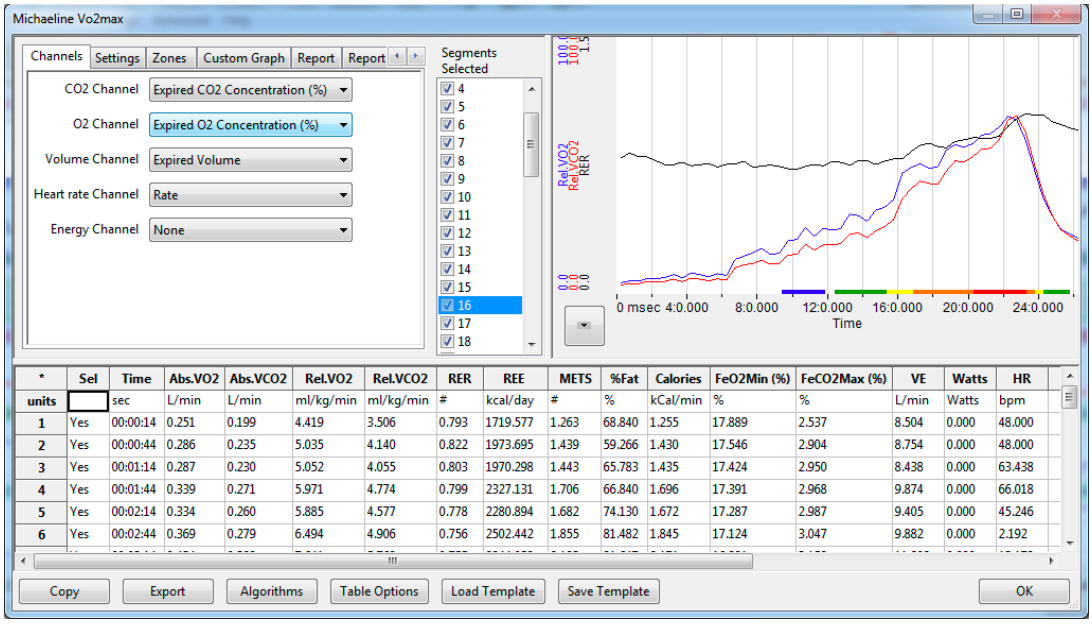
Offline Calculations

After recording is completed

The offline **Metabolic Calculations** dialog allows sophisticated offline analysis of previously recorded metabolic data.

To perform offline analysis:

- Open the recording from the online analysis or another file with previously recorded metabolic data by clicking the **Analysis** button. Or, choose **Offline Calculations** from the **Metabolic** submenu to open the **Offline Calculations** dialog. The panels of this dialog can be resized by moving the mouse cursor over the boundaries until a double-headed arrow appears, and dragging the boundaries to resize the panels.
- Familiarize yourself with the **Offline Calculations** dialog, pictured below.
- The tabbed configuration dialogs are on the upper left portion of the dialog.
- An XY graph window on the right displays the **Metabolic Graph**, showing metabolic data from the selected segments in the **Segments Selected** list.
- Between the configuration dialogs and the XY graph window is the **Segments Selected** list, an editable list of the segments that can be displayed and analyzed.
- The **Data Table** is located on the lower part of the dialog.

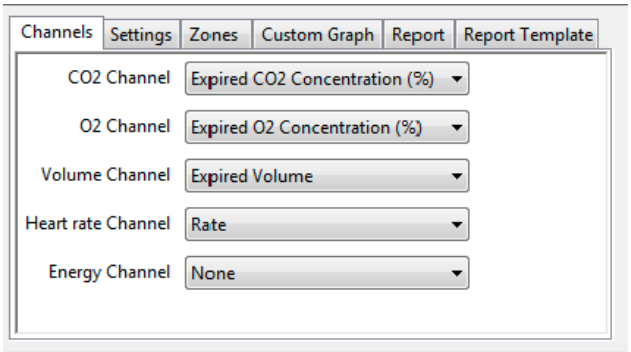


*	Sel	Time	Abs.VO2	Abs.VCO2	Rel.VO2	Rel.VCO2	RER	REE	METS	%Fat	Calories	FeO2Min (%)	FeCO2Max (%)	VE	Watts	HR
units		sec	L/min	L/min	ml/kg/min	ml/kg/min	#	kcal/day	#	%	kCal/min	%	%	L/min	Watts	bpm
1	Yes	00:00:14	0.251	0.199	4.419	3.506	0.793	1719.577	1.263	68.840	1.255	17.889	2.537	8.504	0.000	48.000
2	Yes	00:00:44	0.286	0.235	5.035	4.140	0.822	1973.695	1.439	59.266	1.430	17.546	2.904	8.754	0.000	48.000
3	Yes	00:01:14	0.287	0.230	5.052	4.055	0.803	1970.298	1.443	65.783	1.435	17.424	2.950	8.438	0.000	63.438
4	Yes	00:01:44	0.339	0.271	5.971	4.774	0.799	2327.131	1.706	66.840	1.696	17.391	2.968	9.874	0.000	66.018
5	Yes	00:02:14	0.334	0.260	5.885	4.577	0.778	2280.894	1.682	74.130	1.672	17.287	2.987	9.405	0.000	45.246
6	Yes	00:02:44	0.369	0.279	6.494	4.906	0.756	2502.442	1.855	81.482	1.845	17.124	3.047	9.882	0.000	2.192

The Offline Calculations Dialog

To configure the **Channels:**

Click on the **Channels** tab, opening the **Channels** configuration dialog.

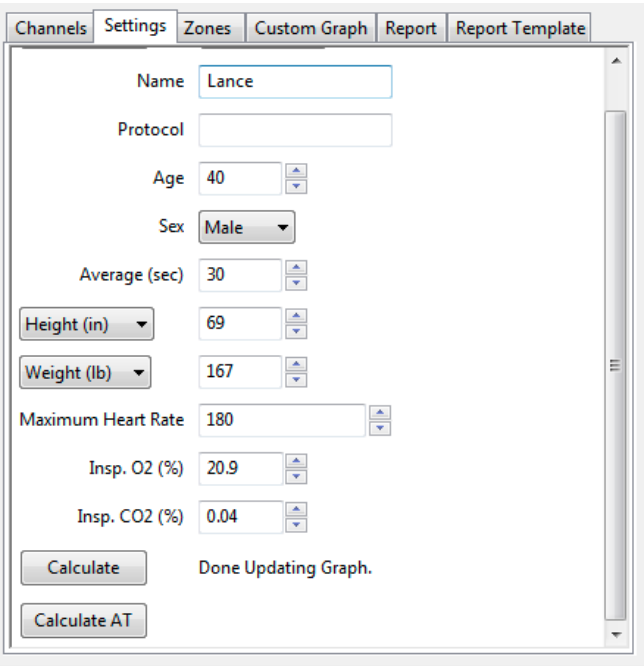


The Channels configuration dialog.

- From the CO2 Channel menu, choose the % CO2 channel from your recording.
- From the O2 Channel menu, choose the % O2 channel from your recording.
- From the Volume Channel menu, choose the breath volume channel from your recording.
- From the Heart rate Channel menu, choose the calculated heart rate channel from your recording.
- Optionally, choose an Energy Channel if there is one on the recording, typically a power output from an ergometer.

To configure the **Settings:**

Click on the **Settings** tab, opening the **Settings** configuration dialog. Most of the information will be filled in automatically.



The Settings configuration dialog.

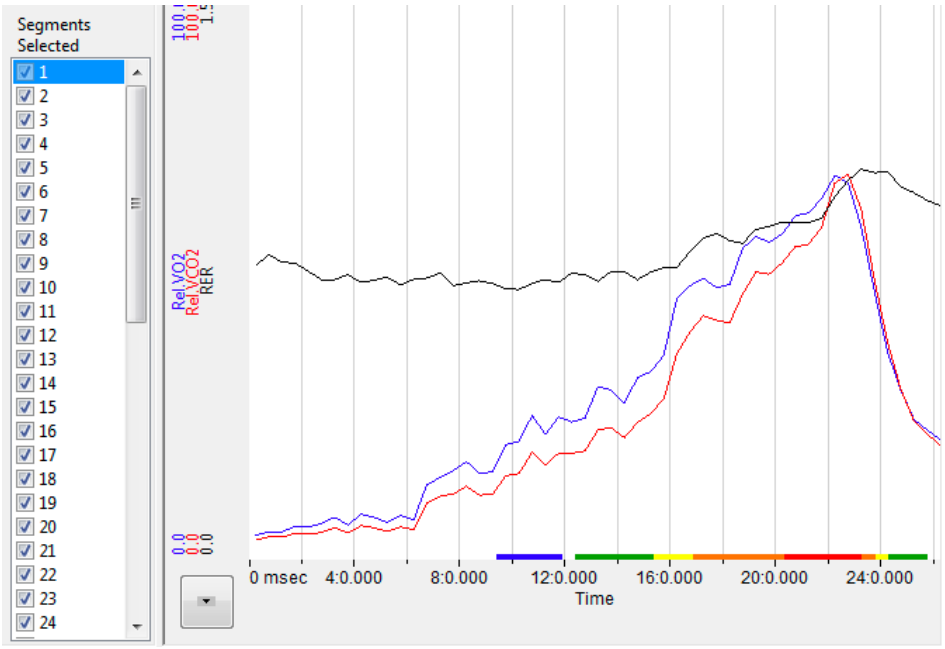
- Enter the subject's name, protocol being used, age and gender in the **Name, Protocol, Age** and **Sex**

text boxes.

- Select the amount of time to average per segment in the **Average (sec)** text box.
- Enter the subject's height (cm or in) and weight (kg or lbs) in the **Height** and **Weight** text boxes.
- Enter the maximum heart rate your subject may attain in the **Maximum Heart Rate** text box. This is typically calculated as: 220 - the subject's age.
- Enter the concentrations of oxygen (usually 20.9%) and carbon dioxide (usually 0.04%) in inhaled air in the **Insp. O2 (%)** and **Insp. CO2 (%)** text boxes.
- The subject's profile can be saved for future experiments by clicking the **Save Subject** button at the top of the dialog. This profile can later be retrieved and entered by clicking the **Load Subject** button.
- By clicking **Calculate**, the **Metabolic Graph** will appear in the XY graph window, and the **Data Table** will be populated with the metabolic parameters. Click **Calculate** whenever settings are updated.
- The subject's anaerobic threshold (**AT**) is calculated automatically, and is shown in the **VCO2 vs VO2** XY graph. This value can be recalculated manually as described in the **Metabolic Graph** section below. Click **Calculate AT** to display the recalculated anaerobic threshold.

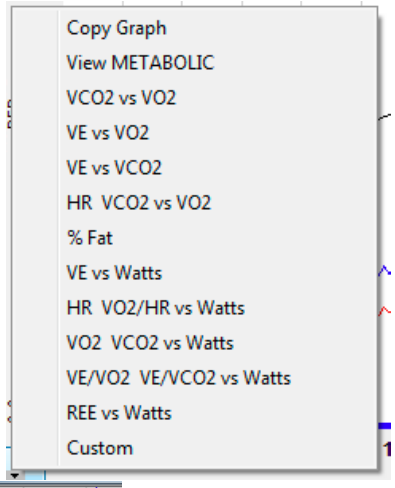
To display and analyze the **Metabolic Graph:**

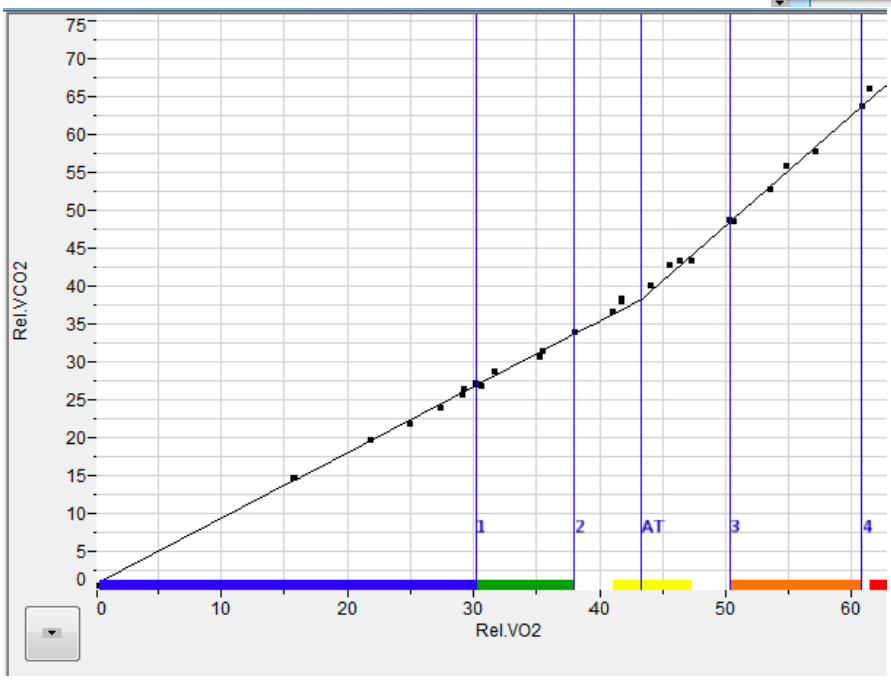
- Familiarize yourself with the **Metabolic Graph**, which will be displayed in the XY graph area for all the segments in the selection and is illustrated below.
  - By default, the graph displayed is of **VCO2**, **VO2**, and **RER** over time.
  - Segments can be deselected (or selected) by clicking on the check box to the left of the segment number in the **Segments Selected** list to the left of the graph. The UP and DOWN arrows on the computer keyboard can be used to move quickly through the individual cycles.
  - The specific parameters shown in the graph can be customized in the **Custom Graph** dialog.



The Metabolic Graph.

- Click the arrow to the lower left of the XY graph window to open a menu with options for the displayed XY graph.
- Click **Copy Graph** to copy the current **Metabolic Graph** to the clipboard. It can then be pasted into the **Journal** or an external application.
- **View Metabolic** displays the default graph.
- **VCO_2 vs VO_2** displays VCO_2 as a function of VO_2.
  - The subject's anaerobic threshold (**AT**) is calculated automatically and is indicated on this graph, as well as the intervals over which the slopes before and after the aerobic/anaerobic break were determined. These intervals (indicated by the markers labeled 1 - 2 and 3 - 4) can be adjusted by moving the markers on the graph. Click **Calculate AT** in the **Settings** dialog to recalculate the anaerobic threshold based on the revised intervals.





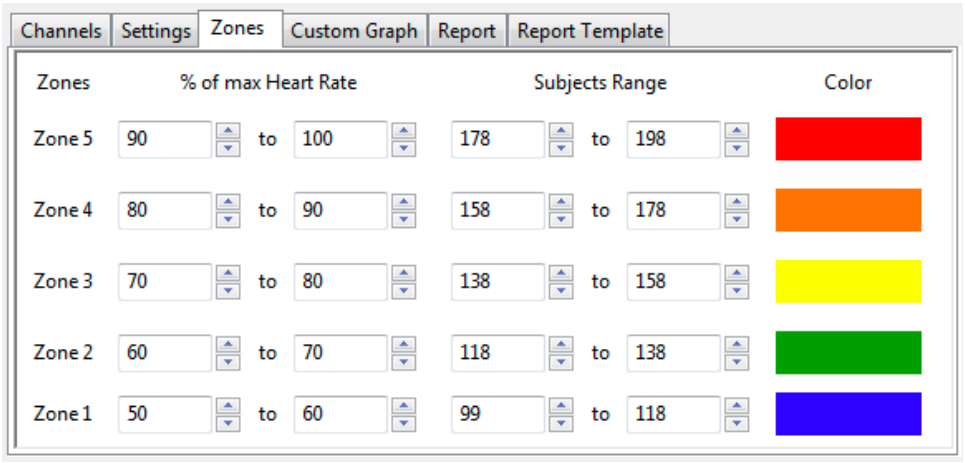
VCO_2 vs VO_2 XY graph with Anaerobic Threshold (AT) indicated.

- **VE vs VO_2** displays the minute ventilation as a function of VO_2.
- **VE vs VCO_2** displays the minute ventilation as a function of VCO_2.
- **HR VCO_2 vs VO_2** displays the Heart Rate and VCO_2 as a function of VO_2.
- **% Fat** displays the calories from fat as a % of total calories burned over time.
- **VE vs Watts** displays the minute ventilation as a function of Watts (requires an Energy channel).
- **HR VO_2/HR vs Watts** displays the Heart Rate and VO_2/HR as a function of Watts (requires an Energy channel).

- **VO_2 VCO_2 vs Watts** displays VO_2 and VCO_2 as a function of Watts (requires an Energy channel).
- **VE/VO_2 VE/VCO_2 vs Watts** displays VE/VO_2 and VE/VCO_2 as a function of Watts (requires an Energy channel).
- **REE vs Watts** displays REE as a function of Watts (requires an Energy channel).
- **Custom** displays a custom graph as configured in the **Custom Graph** dialog.

To configure **Heart Rate Zones:**

Click on the **Zones** tab to open the **Zones** configuration dialog.



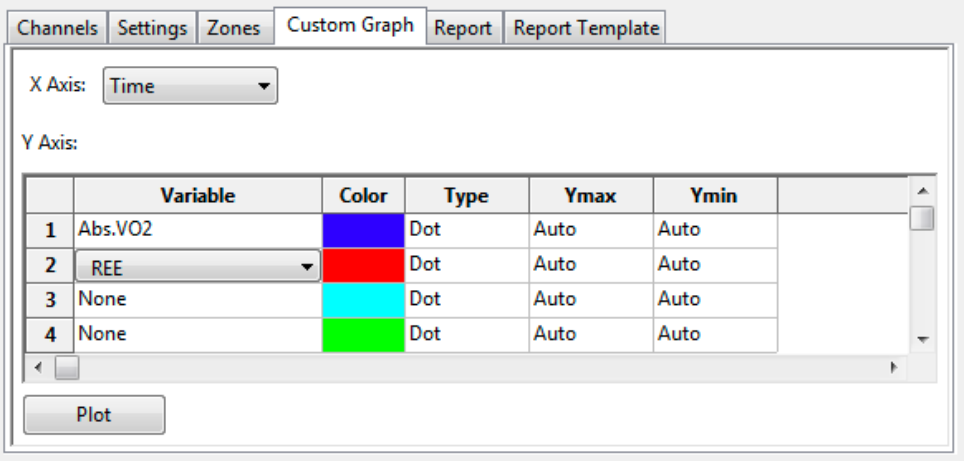
The Zones configuration dialog.

Different heart rate zones are displayed in different colors on the X-axis of the default graph and the **VO_2 vs VCO_2** XY graph. The default zones are automatically calculated based on the subject's maximum heart rate and will typically not need to be changed. If, however, you would like to change the zones from the default settings, it is possible to change heart rate zones by changing the values in this dialog.

To configure the **Custom Graph:**

Click on the **Custom Graph** tab to open the **Custom Graph** dialog.

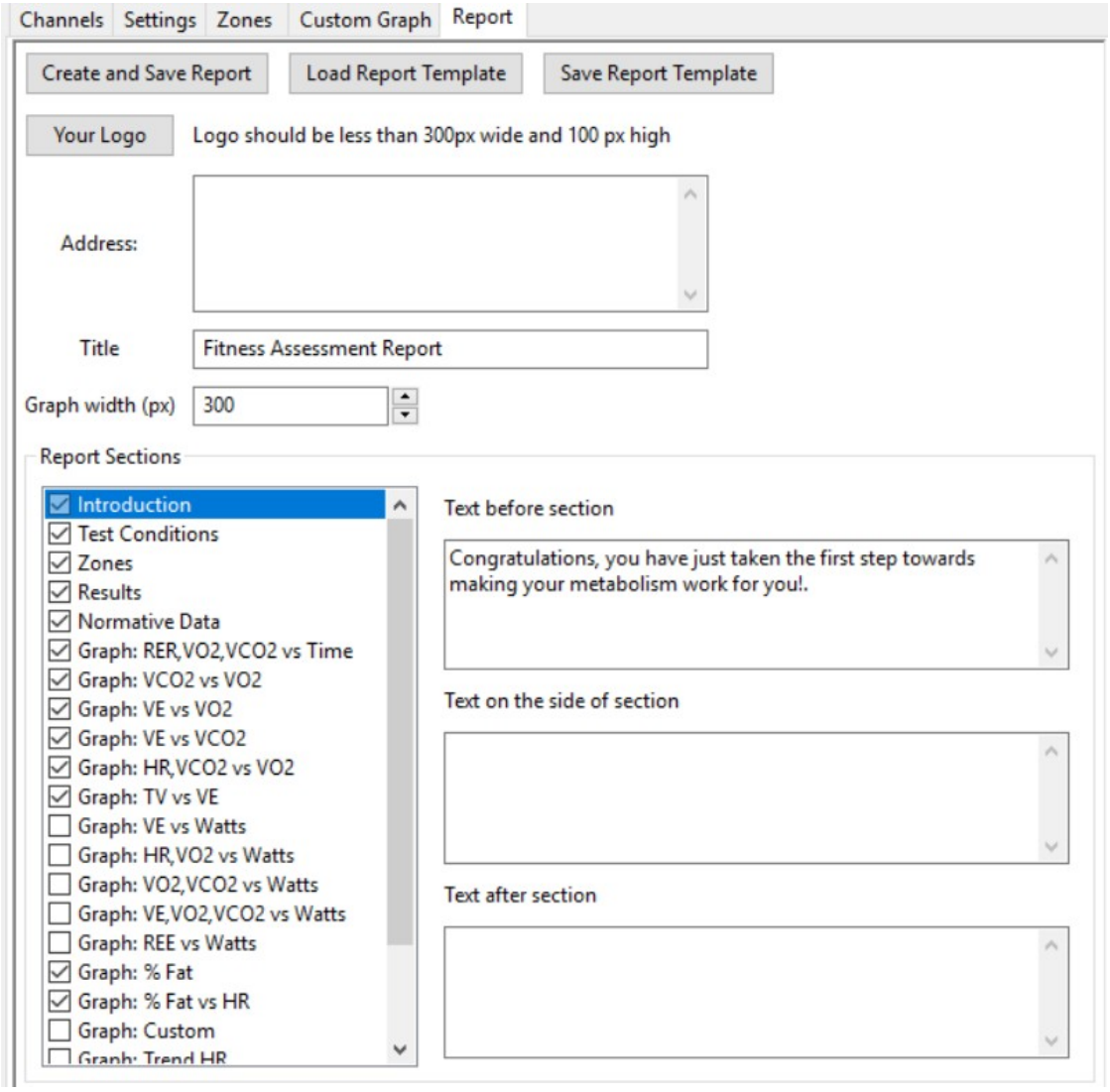
- Choose the variable you would like displayed on the X-axis by choosing one of the variables in the menu next to **X-axis**.
- Choose the variable(s) you would like displayed on the Y-axis by choosing them from the menus in the boxes of the left column next to **Y-axis.**
- Choose the desired color for each Y variable, whether you would like the data displayed as dots or a line, and the Y-axis scale for each chosen variable.
- Click **Plot** to display your custom graph. Choosing **Custom** from the XY graph menu will display the most recently configured custom graph.



To configure the **Report:**

Click on the **Report** tab to open the **Metabolic Report** configuration dialog.

- By clicking **Create and Save Report**, a dated report is generated. This report includes subject information, the metabolic data in table form, and the current set of XY graphs.
- Reports can be customized with a logo, address, title and specific data you want included.
- You can choose which sections are included in the report.
- For each section, the Text at the top of the section, the Text to the side of the section and the text to the bottom of the section can be specified. This text can have html coding, since the output is a html file.
- The size of the exported graphs can be set with the Graph Width (px) setting.
- The Report template can be saved by clicking on the **Save Report Template** button.
- An existing saved report template can be loaded, by clicking on the **Load Report Template** button
- Included in the report are data from previously saved subject data. When **Save Subject** is clicked in the **Settings** configuration dialog, the averaged data from the current experiment are saved as part of the subject profile and when **Load Subject** is clicked in the **Settings** dialog of a future experiment, these data are entered into the **Results** summary that is part of the report, as indicated in the figures below.



Results Summary

Results

Calculation	2012-05-22	2013-01-30	2013-06-13	Units
Maximum Heartrate	187	183	177	beats per min
Heartrate at Threshold	139	143	132	beats per min
Heartrate at aerobic base	111	118	110	beats per min
VO2 max	63.2	65.8	65.7	ml/kg/min
VO2 at Threshold	36.0	44.4	43.3	ml/kg/min
VO2 at aerobic base	19.1	20.4	30.7	ml/kg/min
VCO2 max	77.8	75.9	75.9	ml/kg/min
VCO2 at Threshold	32.0	39.2	38.3	ml/kg/min
VCO2 at aerobic base	19.1	20.5	26.8	ml/kg/min

To use the **Data Table:**

*	Sel	Time	Abs.VO2	Abs.VCO2	Rel.VO2	Rel.VCO2	RER	REE	METS	%Fat	Calories	FeO2Min (%)	FeCO2Max (%)	VE	Watts	HR
47	Yes	00:23:14	3.400	3.581	59.846	63.028	1.053	24832.720	17.099	0.000	17.002	17.273	3.818	101.033	0.000	185.818
48	Yes	00:23:44	2.748	2.868	48.368	50.481	1.044	20024.412	13.819	0.000	13.741	17.225	3.841	80.427	0.000	179.068
49	Yes	00:24:14	2.121	2.222	37.338	39.111	1.047	15472.123	10.668	0.000	10.607	17.389	3.681	65.042	0.000	164.471
50	Yes	00:24:44	1.737	1.746	30.567	30.724	1.005	12537.678	8.733	0.000	8.684	17.221	3.734	50.370	0.000	147.507
51	Yes	00:25:14	1.435	1.421	25.258	25.006	0.990	10322.146	7.217	3.327	7.176	17.315	3.597	42.577	0.000	135.545
52	Yes	00:25:44	1.326	1.285	23.335	22.611	0.969	9487.320	6.667	10.344	6.629	17.332	3.520	39.345	0.000	125.386
53	Yes	00:26:14	1.228	1.173	21.611	20.643	0.955	8756.923	6.175	14.924	6.139	17.378	3.436	36.807	0.000	120.682
55																
56	#		44	44	44	44	44	44	44	44	44	44	44	44	44	44
57	Mean		1.975	1.729	34.756	30.437	0.841	13808.813	9.930	54.380	9.874	16.446	3.872	47.004	0.000	132.031
58	SD		1.056	1.055	18.586	18.568	0.102	7592.239	5.310	31.703	5.280	0.606	0.387	28.146	0.000	36.145
59	Max		3.928	3.940	69.130	69.336	1.053	28183.000	19.751	90.441	19.639	17.389	4.349	112.202	0.000	187.547
60	Min		0.382	0.291	6.723	5.121	0.729	2594.836	1.921	0.000	1.910	15.544	2.865	10.571	0.000	68.868

Metabolic Data Table.

Familiarize yourself with the **Data Table**.

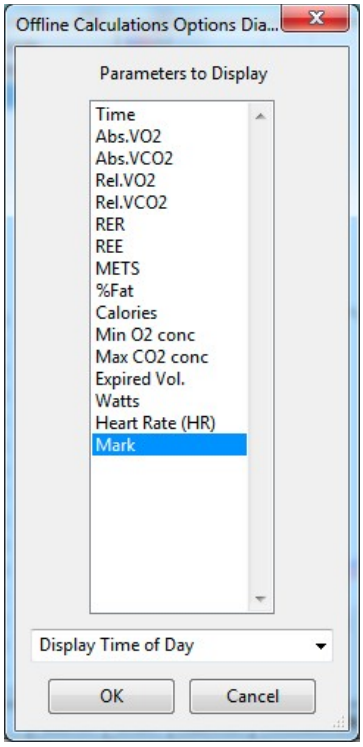
- The **Data Table** spans the lower part of the **Metabolic Calculations** dialog and displays the calculated values for each of the segments in the **Segments Selected** list.
- The top line indicates the **units** for each of the chosen parameters.
- The colors in the left-hand column correspond to the Heart Rate zones configured in the **Zones** dialog.
- The bottom few rows show the sample size, the mean, the standard deviation, minimum and maximum values, and the range of each of the chosen parameters averaged over all the selected segments.

Click the asterisk at the upper left of the **Data Table** to display two options: **AutoSize** and **Copy Selection**.

- **AutoSize** will optimize the size of the **Data Table** boxes.
- **Copy Selection** copies any selected **Data Table** cells to the clipboard.

There are six buttons beneath the **Data Table: Copy, Export, Algorithms, Table Options, Load Template,** and **Save Template.**

1. Click **Copy** to copy all the calculated data in the **Data Table** to the clipboard.
2. Click the **Export** button to export the data as a tab (*.txt) or comma (*.csv) separated text file. The currently displayed XY graph can be exported as a Portable Network Graphics (*.png) or JPEG (*.jpg) image.
3. Click **Algorithms** to display the mathematical definitions of the parameters included in the **Data Table**.
4. Click **Table Options** to open the **Offline Calculations Options Dialog**, which lists the functions from which the **Data Table** parameters can be chosen. All functions are described in the **Metabolic Analysis: Reference** section.
5. Click **Load Template** or **Save Template** to display a dialog allowing you to name and save a specific configuration for future use or to load a previously saved template.
6. Click **OK** to close the analysis.



Metabolic Analysis: Reference

OPTIONAL Calibrate flow head

In order to use the mixing chamber calculations, the flow head must be calibrated. In the lab exercises, a Long Flow Head Calibration (.ixwfcd) file has already been loaded for you and does not need to be replaced.

If you choose to do your own flow head calibrate, detailed instructions for flow head calibration can be found in the **Spirometer Calibration** exercise found in the **Human Exercise-GA200** and **Human Exercise-GA300** folders of the complete *LabScribe* installer. Part of that procedure requires that the **Calibrate flow head** dialog be displayed and completed. A calibration file is generated that can be used in future experiments, which will then require only an abbreviated spirometer calibration process.

Online Metabolic Calculations Definitions

While recording data, many metabolic parameters can be calculated and displayed online using **Online Calculations**. Choosing **Online Calculations** from the **Metabolic** submenu opens the **Metabolic Toolbar** as shown on page 2 of this manual.

The online parameters are:

Time: Time (in seconds) from the start of the recording.

Absolute VO_2 (**Abs. VO_2**): Volume of oxygen consumed in liters per minute**.**

Absolute VCO_2 (**Abs. VCO_2**): Volume of carbon dioxide produced in liters per minute.

Relative VO_2 (**Rel. VO_2**): Volume of oxygen consumed in milliliters per minute per kilogram of body weight.

Relative VCO_2 (**Rel. VCO_2**): Volume of carbon dioxide produced in milliliters per minute per kilogram of body weight.

Respiratory Exchange Ratio (**RER**): VCO_2/VO_2.

Resting Energy Expenditure (**REE**): 5.46 VO_2 + 1.75 VCO_2 (in kcal/24 hr).

Metabolic Equivalents (**METS**): Units of energy expenditure; 3.5 ml VO_2/kg body weight.

% Fat (**%Fat**): Estimate of energy expenditure that comes from fat as a percentage of total calories expended.

Calories (**Calories**): The total number of calories expended.

Minimum oxygen concentration (**FeO_2Min %**): Minimum percentage of oxygen in expired air.

Maximum CO_2 concentration (**$FeCO_2$Max %**): Maximum percentage of carbon dioxide in expired air.

Expired volume (**VE**): Expired air volume per minute at BTPS.

Watts (**Watts**): Measure of power produced during exercise, or rate of energy use.

Heart Rate **(HR)**: 60/period of each cycle.

Mark (**Mark**): Phase of protocol as indicated by associated mark.